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livestock must be improved—using the term "environment' in its widest sense. Such simple improvements as the provision of roofs for protection against rain and sun, the supply of fodder for the dry season, and bedding, are well within the capacity of the people to adopt. Other improvements, not so easy to introduce but equally desirable, are the control of mating, and the control of grazing: little advance can be made with these until grazing land is enclosed. Just as enclosure has had to be adopted in other countries as their agriculture progressed from the pastoral to the "fixed" state, so will it have to come here ultimately.

8. *Selection and distribution of improved varieties of seed.*

A vast field for improvement lies in plant breeding, but it will be non-effective until some of the other measures have received attention, and for practical purposes it can be neglected at present.

Summary. Nearly all the measures suggested above may be summed up in the words "good husbandry"; and "mixed farming" is undoubtedly the key to the situation. Marked improvement in general economic conditions is unlikely to come from concentration upon any single aspect of local agriculture, but from attention to every aspect of the industry as a whole. Having diagnosed the disease, the next step is to carry out experiments to test our ideas upon treatment, before trying to work a cure. Upon this second phase of the work—experimentation—we are engaged at the present time. Our methods of approach to the problem, and the progress we have made so far, are discussed in Part II below.

Part II.

Section I.—Experimental Work.

The detailed study of local farming methods described in Part I enabled suggestions for improvement to be made with reasonable certainty. But the form which these improvements should take and their details could be decided only after careful research. The nearest agricultural experiment station to North Mamprusi is at Tamal in Dagomba, where, as we have seen, conditions differ in practically every respect. It was obvious that very few results from Tamale would apply in the North and that experiments would have to be carried out locally.

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This work was started in 1934 with a few observation plots and minor statistically planned experiments, and each year since then this side of the work has been increased. The aim has been to keep the trials as close to the farmer as possible, that is, simple trials with single issues. Small areas of land were acquired at Zuarungu, Yekeni, Sabiya, and Dagari, in Zuarungu Area, and at Navrongo, in Navrongo Area. In addition simple cultivation trials were laid-down in the farms of the Headmen of Goragu and Yekeni. The location of these places may be seen by reference to the map at the beginning. The method of experimenting in natives' farms has much to recommend it, particularly in a country where vacant land is difficult to obtain; it is possible only with such simple experiments as we have envisaged. It has a demonstration value as a link between the experiment centre and the native farm after preliminary trial, and is useful when a practice is known to be good and it is desired to find out how good.

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The general results of the experimental work will be discussed below in Section I. It is necessary to emphasise that this work is exploratory in nature; in many cases conclusions have been based upon an insufficient number of replications for complete statistical reliability. This is not to say that our results are necessarily untrustworthy, but that they should be treated critically in subsequent stages, before extension. It is useful to have a stock-taking of the information we have gained during the last three years, because we have now arrived at a stage in our experiments when it is necessary to combine the results of individual experiments and to study them together in their place in a complete farming system. All our experience has been leading up to some system of "mixed farming" as a natural corollary (1); what is recorded here is a review of the situation as an introduction to the subject. A general summary and discussion in particular relation to mixed farming is given in Section II. Section I will be discussed under the following headings:—

I. Rotation Experiments.

II. Cultivation Experiments.

III. Manurial Experiments,
  a. manufacture,
  b. utilisation.

IV. Root Crops Experiments.

V. Miscellaneous Trials.

General conclusions are discussed in the text and tables are given in the Appendix IV.

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1. Rotation Experiments.

654 Our survey suggested the desirability of increasing the area planted with root crops and legumes, to serve as famine reserves, supplementary foods for livestock, and to give the land a rest from continuous cereals. Our aim in these trials is to see how far this increase can be effected and at the same time to ensure for the farmer not a less quantity of grain than he was getting before. By the use of animal drawn implements and farmyard manure our experiments seem to show that this will be possible, but it is too early yet to draw definite conclusions.

Sabiya.

Two rotation experiments are being conducted. The first was started in 1934 at Sabiya in "bush" land. The aim was to obtain information upon the best manner in which land not previously cultivated could be exploited. A four-course rotation was followed :—

1st year.	Yams and interplanted late millet	Unmanured.
2nd year.	Early millet guinea corn cowpeas and neri	Manured with farmyard manure 2 tons per acre.
3rd year.	Early millet late millet cowpeas and neri	Unmanured.
4th year.	Early millet groundnuts	Unmanured.

Mean yields per acre are given in Appendix IV, Table I, from which it will be seen that yields so far are most unsatisfactory. This is due mainly to the ravages of pests—locusts, rats, wild-guinea fowl, birds, and white ants in yam seeds. At least we are learning some of the troubles which beset the farmer in the bush.

Navrongo.

The second rotation experiment is being carried out at Navrongo upon a piece of long farmed land acquired by Government some years ago as a possible terminus for the projected extension of the railway to the Northern Territories. The rotation here is similar to the one at Sabiya, except that sweet potatoes, cassava, and Coleus potatoes are included in the root area, and

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the experiment is being run as a unit farm of 8 acres by a man and his family with 2 bullocks as a mixed farming experiment. The mean yields obtained in 1935 and 1936 are given in Appendix IV, Table 2. It is interesting to observe that in 1936 early millet and guinea corn following a previous yam crop gave nearly a 100% better yield than where they followed sweet potatoes.

It is too early to express any opinion upon these rotations at present.

II. *Cultivation Experiments.*

As already described in Part I (Preparation for Planting), the native practice is to plant the main crops of cereals upon the previous season's stubble without giving any preliminary cultivation. With hand cultivation alone it is not possible to cultivate a very big area during the time between the first and second rain of the year, and we know that to miss the planting rain with early millet is serious. The introduction of animal drawn implements has completely altered the situation. It is possible with a cultivator or a plough to loosen the soil over a large area before the land dries out after the previous harvest, and we have found that each year that land is ploughed makes it easier to work. The local West African Shorthorn cattle stand up quite well to work. The questions we set ourselves to answer in our experiments were: "what is the best kind of cultivation under average local conditions, *i.e.*, ridge or flat?", and "what implement, or implements, can do this most economically?".

Implements used.

So far we have experimented with the following :—

Ransomes "DY" ridging plough,
" "M.S.N." single furrow plough,
" "Punjab" " " "
" "Victory" " " "
" BTSL cultivator,
Nigerian 5 tine iron cultivator from Kano,
Nigerian pattern 3 tine cultivator made locally upon a log frame.

Ridge Cultivation v. Flat.

So far experiments suggest that under the light soil conditions here, the combination of Ransomes DY ridging plough and the Nigerian pattern wooden cultivator will prove the most economical

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654 combination. Experiments over the last three years show a definite advantage in favour of ridging (see Appendix IV, Tables 3-7) as against flat cultivation; although, as might be expected, the effect upon yield varies in different places and in different seasons. Some of the advantages in favour of ridging are:—

1. Planting in straight lines is simplified and subsequent inter-cultivation is made more easy.

2. Contoured ridging is particularly useful as a measure to check soil erosion.

3. Cultivation can be extended to fertile valley lands too wet to grow crops on the flat.

4. Manure is concentrated in the middle of the ridge where feeding roots can make most use of it.

It has been found that with a DY plough an acre or more can be ridged in a day by a pair of bullocks working in the morning and in the evening. Excellent ridges are being made in Tamale by the Officer-in-Charge using the single furrow "Victory" plough, but since this involves going over the land twice we may find here in the Northern Province, with precarious early rains and a large area of early millet to plant, that the more quickly made, though possibly less efficient, ridges of the DY plough will suit us better. This matter will receive attention in the future.

III. *Manuring.*

a. *Manufacture of Manure.*

In the improvement of local agriculture attention to cultivation and manuring must be given together, for the one cannot take full effect without the other. The effects of quite small dressings (2 to 5 tons per acre) of native compost upon crop yields (see Appendix II, Tables 6 and 7) leave no doubt as to the order of improvement which we may expect from attention to this subject. The amazing growth of crops in the immediate vicinity of compounds tells its own story. But as we have seen, only 12% of the total area of land cultivated upon native farms receives a dressing of manure, and this is quite inadequate to maintain fertility under a system of continuous cultivation. We set ourselves to find out, therefore, how, with a reasonable head of stock, we could make manure in the biggest quantity and of the best quality. Green manuring could not be considered locally for obvious reasons; some form of compost or pen manure was envisaged, or a combination of the two.

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Compost.

Since the native manure is a compost, inefficiently prepared from vegetable waste and the sweepings of animal manure from the compounds, we turned our attention first to the manufacture of compost on the lines advocated by Sir Albert Howard at Indore (15). A battery of pits was laid down at Zuarungu in 1935 and "Indore" compost of excellent quality was prepared. (For analysis see Appendix IV, Table 8). But as Sir Frank Stockdale pointed out during his visit to Zuarungu in 1935, the process was far too complicated for the local native to adopt at present; and the shortage of water in the dry season would make it impracticable during half the year. The experience we gained of the decomposition of organic matter was valuable however. The method has now been discarded in favour of the manufacture of farmyard manure.

Farmyard Manure.

By farmyard manure is understood the material which results from the decomposition of cellulosic wastes—mainly cereal stalks and grasses—supplied as bedding to livestock; it receives the dung and urine from the stock and is trampled and allowed to accumulate under foot. Farmyard manure forms the basis of most systems of arable farming in the world; it has been adopted in Nigeria (3), Tanganyika (16), and elsewhere, in mixed farming; and we have adopted it here with most satisfactory results. It has been found that a pair of bullocks will produce about 5 tons of manure of good quality in a year, and a donkey, just over two tons.

The stock are housed in a pen, part of which is open, and part covered. The manure is allowed to accumulate in the covered part where clean grass bedding is added every morning. In the open part resistant material, like guinea corn stalks, is trampled and soaked with rain in the wet season; as it gets broken up it is thrown into the covered part together with any dung dropped outside. The junction of the walls and floor of the pen is rounded, and the floor is made saucer-shaped to reduce air pockets. Very little fly breeding has been found to take place and, if sufficient bedding is supplied, the pen keeps "sweet" and clean. So far only working bullocks and a donkey have been kept in this way. It has been suggested that the method may not be satisfactory with smaller stock and calves.

Human Health.

From the standpoint of human health we have convinced the local Health Authorities that so far from being insanitary, our method of manufacturing farmyard manure actually represents an

advance in domestic sanitation over the present native practice. We are agreed, however, that it is desirable to keep stock separated from the peoples' living quarters; that a roof is essential in the rainy season; and that clean bedding must be put down regularly and in adequate quantities. (It will be remembered, see page 33, that the present native practice is to keep livestock at night within the compound with no litter, upon an unbeaten floor, which is only irregularly cleaned out, and there is no roof protection; this dirty yard has to be crossed in passing from the entrance of the compound, to the living quarters.)

b. *Utilisation of Manure.*

Manurial experiments have been carried out at Zuarungu and Navrongo since 1934 using small dressings, 2 tons or 4 tons, of farmyard manure, "Indore" compost, and native compost. (The manure used in the 1934 experiments was leached cattle dung of doubtful value.) Mean yields obtained in these experiments are given in Appendix IV, Tables 9 to 13. It will be seen that these small dressings of manure resulted in yield increases of up to 80% over the yields from controls, unmanured. It should be noted, however, that nearly all our yields compare very unfavourably with yields upon native farms. The reason for this is that our experiment centres, in every case, are situated upon land completely out of condition. Nevertheless our results are valid within the limitations of the trials.

Residual Values.

Residual manurial trials at Navrongo showed statistically significant values remaining after the application of 2 tons and 4 tons of dung to sweet potatoes, coleus potatoes, and mixed cereals, in 1934, upon subsequent cereal crops in 1935 and 1936. The residual effect of manure in these trials in 1936 was more marked upon the vegetative growth early in the season, than was reflected in the yields.

Optimum Dressing.

Our experiments so far suggest that the optimum dressing of manure under local conditions is probably from 2 to 4 tons per acre, and that such a dressing is desirable at least once in four years. It should be mentioned here that this is the optimum under present conditions; with an increase in livestock, and the introduction of stall feeding, the amount of manure available will be increased and heavier dressings may be practicable. So far we

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have refrained from experimenting with anything outside the capacity of the better farmers in the district to adopt; it would be of little value to us to know, for instance, that ten tons of manure per acre are desirable, when the maximum amount available is say three or four tons. And if these small dressings were not satisfactory we should have to consider other measures for maintaining fertility. 654

IV. *Root Crops.*

The desirability of increasing the proportion of land planted with root crops has already been stated. Experiments have been conducted with the following crops: yams (Dioscorea spp.), sweet potatoes (Ipomoea batatas), cassava (Manihot utilissima), and Coleus potatoes (Coleus dysentericus). The conclusions reached with regard to each are discussed below.

Yams.

Yams are the staple crop of the Mamprusis and Dagombas further South, and except for one or two special areas near the Volta Rivers—South Kusasi and South East Zuarungu—where conditions resemble those in Mamprusi, they are practically not grown at all in North Mamprusi. Yams are imported, however, and sell for very good prices in local markets. Ill considered attempts to introduce yams in the past had not met with much success (a notable exception being Chana, in Navrongo Area), and it was considered desirable to explore the situation by experiment. [244]

Our experiments have taken the form of variety trials and two Dagomba varieties, Kuki and Puno, have proved outstandingly the best yielders in every trial, see Appendix IV, Tables 14 and 15. But even the best yield from these does not compare with an indifferent yield in Dagomba. Nevertheless, a low yield of saleable tubers might prove profitable for sale locally as a luxury crop. In a season when rains come early and keep on late, yams yield fairly well; but since the early and the late rains are notoriously variable in North Mamprusi, yams must always be regarded as a gamble and only small scale planting is recommended. A point in favour of yams, which was brought out in the Unit Holding Rotation Experiment at Navrongo in 1936, is the remarkably high residual value of the heavy yam cultivation by comparison with the cultivation for sweet potatoes; this was shown by the yields of a subsequent mixed cereal crop. (The difference was nearly 100%.) A small area of yams would appear to be worth including in unit holding trials.

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Sweet Potatoes.

•654 Three local varieties of sweet potatoes have been tested at Zuarungu and Navrongo—NANURI-SUNGA, NANURI-PUNGA, and NANURI-YADAGA. Of these, the last two have proved the easiest to establish and the most consistent yielders. The first has therefore been discarded. Results of these trials are given in Appendix IV, Table 16. Our yields so far have not been very satisfactory (between 2 and 3 tons per acre of tubers), but the reason for this has been due largely to the difficulty of obtaining sufficient planting material. There can be no doubt as to the value of this crop in a system of mixed farming locally. The tubers and tops provide very palatable fodder for livestock in the early part of the dry season when grazing becomes of poor value. The importance of the crop as a famine reserve for the people in years of locust invasions requires no stressing. Our practice is to plough up a ridge of sweet potatoes a day, as required for feeding. The tubers keep quite well in the ground until the end of February. Sun-dried, sliced tubers were found to keep very well for the whole of the dry season. There is undoubtedly a big future for this crop, and we are including a large proportion of it in the root area on unit holdings.

Cassava.

We have not very much information upon this crop in North Mamprusi. Observation plots at Zuarungu and Navrongo were planted in May and June, 1935, and yielded at the rate of from 2 to 6 tons of tubers per acre in February and March of 1937, having occupied the ground for about twenty months. Cassava is of particular value upon the mixed farm as a succulent food for livestock during the period from mid-February, when sweet potatoes start to rot in the ground, until the fresh grass is ready for grazing in mid-April. And as a famine reserve crop it is renowned the world over. But whilst cassava is obviously a desirable crop to grow, it is quite impracticable upon native farms at present because of damage by livestock, principally goats, during the dry season. Under different conditions, *i.e.*, with enclosure, or attention to the control of livestock, cassava could come into its own. The difficulty might be solved if everybody planted it; for individuals to do so without fencing would be a waste of time.

Coleus Potatoes.

This small tuber is of no great importance, but a small quantity is included in Unit Holding experiments since the people normally devote a small area to it. Coleus potatoes do not store well and yield between 1 ton and 1½ tons of tubers per acre under favourable conditions. As a stock food they cannot compare in value with sweet potatoes or cassava.

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V. *Miscellaneous Trials.*

Under this heading experiments with groundnuts and rice will be discussed and observation plots of Sesamum indicum, "acha" grass (Digitaria exilis), Bengal beans (Mucuna spp.), Dolichos lab-lab, Dolichos biflorus, Calopogonium mucunoides. 654

Groundnuts.

Groundnuts are next to cereals in importance in North Mamprusi. They grow very well upon the sand drifts and their value as a potential export crop, as well as an important stock food, gives them a high place in cropping on a mixed farm. Experiments have been confined to testing the merits of selections from "bunch" type Nigerian groundnuts, imported for the groundnut scheme at Ejura in 1933, against the local procumbent variety. In three years of trial the Nigerian variety has proved itself to yield rather better than local and its habit of growth enabled a saving in labour at harvest of 30% to be effected—an important consideration upon a mixed farm. Mean yields obtained in these trials are given in Appendix IV, Table 17.

Rice.

Trials over three years proves conclusively the value of rice locally. It yields a bigger weight of food for man and for beast from a given area, than any crop we have tried so far. Variety yield trials have been carried out to test Local rice, Tamale selections—black husk, and yellow, and Essiama selections, NZ2 and NZ4. Of these, Tamale Yellow has proved itself to be the best; in 1936 it yielded nearly 1,500 lbs. of paddy to the acre and 5,900 lbs. of straw. The working bullocks eat the straw very readily during the dry season. Mean yields from rice trials are given in Appendix IV, Table 18.

Sesamum Indicum.

Odd plants of this crop are occasionally found in North Mamprusi, and following a visit of Dr. W. E. McCulloch, Dietetics Research Officer, Nigeria, in 1931 (17), great hopes were entertained from its extension. Trials have not given satisfactory results however. The plants were severely attacked by caterpillars and growth was not uniform. Planting in the third week of May upon ridges 3' apart was found to be most satisfactory. Early thinning was found to be essential. Trials have now been discontinued in favour of other crops.

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654 *"Acha" Grass (Digitaria exilis).*

Observation plots of this small grain plant have been found easy to establish. Yields of up to 470 lbs. of grain per acre have been obtained and 22 cwts. of hay. It is considered however that time and space can be more profitably devoted to other crops, and trials have not been continued. Acha grass has a possible value as a trap crop for the parasite Striga, sometimes a serious pest locally on guinea corn.

Pigeon Peas (Cajanus cajan).

Pigeon peas are not grown locally. Observation plots show that in a long rainy season the crop will grow quite well, but, since it ripens in the dry season, it suffers from damage from livestock in the same way as cassava. Trials are being made with early maturing strains from Pusa, India.

Green Manure and Fodder Crops.

Observation plots of Bengal bean (Mucuna spp.), Dolichos biflorus, Dolichos lab-lab, and Calopogonium mucunoides, have been planted at Zuarungu and Navrongo, and of these, Bengal beans have proved to be outstandingly the best. But all ideas of green manuring have now been given up in favour of farmyard manure; Bengal beans have a value, however, as a fodder crop and small areas are grown for this purpose.

Gum Arabic.

Hopes were entertained at one time of finding in the gum from Acacia Senegal an export crop from North Mamprusi. The tree is found in large numbers in a belt running through the district. Repeated tappings produced very poor results and it is considered that the "harmattan" is not sufficiently severe to cause the tree to respond. Trials have been discontinued.

Section II.—Discussion of Findings in Particular Relation to "Mixed Farming".

In West Africa the term "mixed farming" is used to describe a system of agriculture in which livestock and land are complementary (1). With a pair of bullocks and a plough, from 8 to 12 acres of land can be cultivated instead of the usual 2 to 4 acres by hand methods; and by the use of the farmyard manure made by the working bullocks and other stock a farmer might have, this area of land can be maintained at a reasonable level of fertility, and the wasteful practice of "shifting cultivation" can be eliminated. Depending upon circumstances, the extensive use of the plough is important and a high yield per man farming is the

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aim; or alternatively, the intensive use of manure is important and a high yield per acre is the aim. Observations made during a visit to Nigeria in 1936 to study mixed farming are recorded in Bulletin No. 33 of the Department (3). We are starting to-day where Nigeria started ten years ago and Nigerian experience is valuable to us here as a guide. The best mixed farming system for North Mamprusi, however, must be worked out to suit our particular conditions. These conditions are discussed below. 654

Intensive System Required.

That conditions are ripe for the introduction of mixed farming has already been shown. The cultivators of the soil own livestock and practice a system of fixed cultivation relying, in part, upon regular manuring to maintain the level of crop production. But the system is not nearly so intensive as conditions demand. It is therefore the intensive use of manure with a high yield per acre which is important here.

Animal drawn implements, though necessary to enable the manure to take full effect, come second. In passing, it may be mentioned that herein lies the main difference between a system for North Mamprusi and one for South Mamprusi and Dagomba. In the South, where land is abundant, the extensive use of the plough will be important, with possibly a combination of green manuring and farmyard manure. North Mamprusi resembles the Kano "suburban areas" in Nigeria.

Conservation of Organic Matter.

"Non-burning".

The first step, which it is within the power of every farmer to adopt without the expenditure of capital, is to conserve all the waste vegetable products from the farm and from waste land (grazing areas, roadsides, fallow) for use as fodder, or if too coarse, as litter, for livestock. This implies control of the wasteful practice of burning. A good start was made in Zuarungu Area in 1936-37 season through the Native Administration; during this period practically no wide scale burning took place. This measure alone is likely to have far reaching effects for the welfare of the district, quite apart from its essential relationship with mixed farming. These effects will be cumulative and will not be appreciable in a single year; some of the more important advantages which may be expected are:—

1. Organic matter, in which local soils are particularly deficient, will be conserved for use as the basis of farmyard manure.

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654 2. Livestock fodder can be obtained for the dry season by cutting grass for hay before the onset of harmattan, and by the conservation of cereal and legume leaves.

3. Grazing lands will be improved, both in the stock carrying capacity and in the length of the grazing period.

4. Soil erosion will be considerably reduced (and less damage to roads). Control of vegetation must always be the first anti-erosion measure.

5. Tree growth will be assisted, both timber—notably deficient—and fruit. (Figures from Yendi Shea Reserve, in Dagomba, show this.)

6. Tree population will increase due to more successful regeneration.

7. Water-table of district will have a higher average height throughout the year, due to a slower rate of percolation, less run-off, and decreased evaporation.

8. Less danger from shortage of roofing grass. (This is likely to become increasingly important as flat roofs must give way to thatch, due, in part, to a growing shortage of strong timbers.) It might also be mentioned that there is a small market for grass, used as fuel in the producer gas engine, at Nangodi Mine.

Against "non-burning" very little can be said in North Mamprusi, In a few swamp areas burning might be desirable to check the development of acid conditions, and on the edges of bush land, as around Pwalagu on the Volta River, tall grass—tall because there is not sufficient population to cut all that is available—might encourage lions to come unpleasantly close to the houses. The control of cattle ticks has been suggested, but regular "dipping" is the remedy for these. Care must be taken to see that grass in waste places and on grazing lands is cut before the middle of December, for a late burn is more serious than the usual burn in November and December, and the risk will be ever present. It must be stressed here that it is not sufficient merely "not to burn"; if the grass cannot be kept close by grazing, coarse, dead grass must be cut down during the dry season, to enable the fresh grass to come through at the beginning of the following rains. (This is one of the reasons why "non-burning" is applicable at present only to areas where the system of cultivation is "fixed" and grass and grass-land is scarce and valuable because the proportion of arable to grass is high. In South Mamprusi and Dagomba, "shifting" cultivation is the practice and the proportion of arable

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to grass ("bush") is infinitesimal; the comparatively small population cannot possibly use all the grass available, and cannot, and need not, try to prevent burning; although they can ensure an early burn in many places with advantage. The difference between the two sets of conditions has been frequently ignored in discussions on the subject in the Northern Territories.) It is interesting to observe that burning of the veld is condemned in South Africa and parts of East Africa, and controlled by strict legislation. 654

Manufacture of Manure.

If the material conserved in the way described above is supplied as bedding to livestock, manure of excellent quality can be made by the method explained on page 45. It is desirable to feed stock on the farm as much as possible so that the loss of the dung and urine is reduced to a minimum. At least three times as much manure can be made in this way with a given head of stock than the native makes at present; and furthermore, farmyard manure is richer in plant food than native compost (see Appendix IV, Table 8). The output of manure from a mixed farm with an average stocking of say 2 working bullocks, 1 cow and calf, 1 donkey, 3 sheep and 6 goats (c.f. average stocking per compound, text Table 5, page 32) would be at least 8 tons per annum. Yields from native farms, see text Table 4, page 30, and from our experiments, page 46, show an average crop yield increase of up to 80% from the use of such small dressings of manure as 2 to 4 tons per acre; and residual trials show a value remaining in the third season after application. The average area of land farmed by a compound is nearly 8 acres; thus, with the stocking we have assumed, about 25% of the whole farm could be dressed with manure at the rate of 4 tons per acre in each year, instead of a smaller average dressing upon 12% of the area.

It will be seen that by the extension of this aspect of mixed farming alone—the means for which already exist and involve no more than the time of the farmer, of which he has an abundance, and the trouble of collecting and utilising the waste materials already everywhere in the district—much can be done towards ensuring an adequate food supply for the people, and better conditions for their livestock.

Animal Cultivation.

But whilst to increase soil fertility by the use of manure is a big step forward, not to improve methods of cultivation at the same time would be to lose much of the potential value of that fertility; manuring and cultivation must go hand in hand. Animal cultivation provides the solution. Admittedly more than half the farms

654 in North Mamprusi are too small in area, too irregular in shape, too stony, or too hilly, to allow of economic animal cultivation, but there is also a large number of farms—more than we can hope to affect for many years to come—which are suitable, and it is upon these that we must concentrate. With expansion in the future, it is probable that land will be specially selected because of its suitability for animal cultivation, but this time is sufficiently far ahead not to concern us at the moment, although it would be well to keep it in mind. Local West African Shorthorn bullocks have been found to be easy to train and to handle, and to be sufficiently heavy for ploughing the light soils of the district; although an increase in size would be helpful. Experiments have shown that the type of cultivation best suited to our conditions is to plant crops on ridges, and that by using a light scuffling and ridging plough, and a simple cultivator, one man and a boy, with his wife to assist in planting, can farm an 8 acre holding with the work of two bullocks. Not only is this area three times the size of the area a man cultivates by hand at present (see page 18) but the cultivation is more efficiently performed. These factors, taken into consideration with manuring, already discussed, give some idea of the scope of the improvement at which we are aiming.

Economics of the Plough.

What we have yet to prove, however, is that within a reasonable period, say four years, a farmer will receive a return from the use of bullocks and bullock drawn implements to cover the original cost of the implements, and to provide reasonable interest on the extra farming capital invested, and for his enterprise. Unless we can prove conclusively that mixed farming is profitable no amount of demonstration can extend the use of the plough upon any great scale; neither can we put up a case to Government or the Native Authority for loans to supply the initial farming capital. The proof lies in the actual returns obtained from experimental unit holdings. The free distribution of implements to Chiefs and Headmen will not demonstrate the economic value of these implements; we know that a plough can work locally, but can it work profitably? Let us examine the matter more closely.

Export Essential.

Since the plough is an imported article it follows that for every one which comes into the country, something of an equivalent value must go out, directly or indirectly. It has been shown that the high cost of road transport rules out the possibility of an export crop for an overseas market (1 and 18). It is in this respect that we are at such a disadvantage by comparison with Northern Nigeria, where cheap rail transport enables cotton and groundnuts

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to be profitably exported from distances more than 600 miles from the coast. The alternative is a local export to some part of the country with money to spend; the obvious solution lies in the export of livestock to Ashanti and the Colony.

Livestock Industry.

The conditions under which livestock are kept in North Mamprusi have been fully discussed under the heading "Animal Husbandry", pages 31 to 33. It has been shown that whilst livestock are used mainly for uneconomic purposes, marriage dowries and sacrifice, they are becoming increasingly regarded as a source of money; and with the rapid development in money consciousness which is proceeding to-day, there is no doubt that the value of livestock will become to be recognised more and more. Survey showed that 54% of compounds (probably rather less over the whole district) owned cattle of the West African Shorthorn type. Bullocks find a ready sale to butchers' agents at prices varying from £1 10s. to £3 15s.; and milk, in the form of curds, is sold in local markets. Nearly all compounds own sheep, goats, fowls, and guinea fowls, and the trade in fowls is already very well established. The market for livestock in Ashanti and the Colony is practically unlimited; only a very small proportion of the meat slaughtered is locally grown. But if this proportion is to be increased, local methods of animal husbandry must be improved. Attention to breeding alone is not enough, as the Director of Veterinary Services pointed out in his Annual Report for 1935-36 (12). And because the bulk of the livestock in the Gold Coast belong to the cultivators of the soil, it will be seen, that the development of mixed farming is just as necessary for the future of the livestock industry, as the development of the livestock industry is for the future of mixed farming. Thus the ultimate justification for the investment of capital in working bullocks and cattle-drawn implements must be in the export of livestock. Work with livestock is necessarily slow, but if good feeding and good breeding produce an improvement in the local stock equivalent to the improvement effected in Northern Nigeria, by attention to these matters with Zebu cattle (13)—and there would seem to be no reason why it should not—we shall have little difficulty in justifying the cost of a plough, when local unimproved bullocks are worth nearly £4 a head to butchers' agents at the present time.

Sale of Surplus Foodstuffs.

But before livestock receive better treatment the people themselves must have sufficient food, and it is by the sale, as food upon local markets, of a surplus of production over individual requirements that the first mixed farmers are likely to receive a return. At the present time, large quantities of grain are imported from

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The limiting factor for the rapid extension of mixed farming is likely to be the people themselves. But at least we must prove and demonstrate our system before we can say that the people will not follow. Chiefs and Headmen must lead the way. The best means of extending our results is through the machinery of the Native Administration, a section of which will have to be adapted and organised for the purpose. It is considered that the extension of proved agricultural results is as much a political problem, if not more so, than an agricultural problem.

Much careful research work requires to be done before a system suitable for general adoption can be recommended. But we have sufficient information to proceed quietly with extension work in the case of school farms, Chiefs, etc. Undue haste at the present time might seriously jeopardize future chances of success. That there will be difficulties in the future is certain; it would be well to bear in mind, however, that it is only the good farmers we can help, farmers above the average; and the number we can effect in the early stages will be very small.

Most of the requirements for mixed farming already exist in the district; organisation and farming capital are lacking. That the local farmers already own cattle and practice fixed cultivation and regular manuring, are points in our favour by comparison with Nigeria where very few peasant cultivators owned cattle. There will be no return to the tedious hoe system of farming once the advantages of the new system have been appreciated. The introduction of mixed farming offers undoubtedly the best basis for the introduction of all other measures designed for the welfare of the natives in North Mamprusi.

School Farms.

A start with demonstration has been made in 1937 by establishing mixed farming units attached to the Native Administration Schools at Sandema and Bawku. These farms consist of 8 acre units run by two paid labourers using a pair of bullocks, a plough, and a locally made cultivator. The boys assist with planting, and light operations such as thinning. The purpose of school farm is a dual one: they are intended, firstly, to produce food as economically as possible to reduce the schools' messing expenses; and secondly, as ocular demonstrations of improved methods of farming for the pupils. Many of the boys at these schools will become chiefs of the district: for them to see and assist with our methods of farming through a number of consecutive seasons, makes the time we devote to school farms a valuable investment; the dividends we shall reap in future extension work. The size of

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these farms is limited at present by the amount of manure available; it is hoped in the future to increase the stocking by the addition of a cow, or cows.

N.A. Demonstration Farms.

In addition to the school farms, we are starting two demonstration farms in 1937. One is at Bongo, ten miles North of Zuarungu, the other, at Garu, South of Bawku; both are being paid for entirely by the Native Authority. At Bongo, in the centre of a thickly populated area, we are demonstrating the intensive use of manure upon a six acre holding, with food crops, and later, fowls, as saleable produce. At Garu the farm is eight acres in area, with room for expansion; groundnuts, and later, cattle, are intended to be the saleable produce here. The dry season feeding of stock and the manufacture of farmyard manure are the features most stressed at present. A point in connection with these mixed holdings which is sometimes forgotten is that it takes at least three years to get one working as a self-contained unit, that is, the fodder and bedding which is grown in 1937, is used in 1938, and forms the basis of the manure for the 1939 season. We are coming up against a number of practical difficulties in the first year, the chief of these being: inexperienced staff and labour, newly trained cattle, stumps and outcrops of stones in the farms. Very late rains in 1937 season have not been in our favour.

We have made a start and before going any further it behoves us to consolidate this start during the next two seasons. It is unlikely that we have found the best system for local conditions from the beginning, and we shall learn much from the experience of the next two years.

Training of Staff.

There is an immediate need for a small experimental stock farm, and for facilities for instructing the staff in some of the principles of animal husbandry if mixed farming is to make steady progress. The curriculum of the farm school run by the Nigerian Agricultural Department at Samaru, near Zaria, would be a valuable guide to what is required in this respect.

Summary.

1. A brief description of the climate, vegetation, soil, population, and economic and social conditions in North Mamprusi, is given in Section I of Part 1, as an introduction to the study of local agriculture.

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APPENDIX IV.

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MEAN YIELDS FROM EXPERIMENTS.

ROTATIONS.

Table 1.—Rotation Experiment, Sabiya.

„ *2.*—8 acre Unit Holding Experiment, Navrongo.

CULTIVATION EXPERIMENTS.

Table 3.—Ridge cultivation v. Native method at Goragu.

„ *4.*—Ridge cultivation v. Flat cultivation v. Native method at Yekeni.

„ *5.*—Ridge v. Flat v. Native at Zuarungu.

„ *6.*—Ransomes M.S.N. plough v. Native method at Zuarungu.

„ *7.*—Ransomes "Victory" plough v. Native method at Zuarungu.

MANURING EXPERIMENTS.

Table 8.—Analysis of Manures used at Zuarungu in 1936—Native compost, "Indore" compost, and farmyard manure.

„ *9.*—Manurial Trial on sweet potatoes and residual values, Navrongo.

„ *10.*—Manurial Trial on Coleus potatoes, Navrongo.

„ *11.*—Manurial Trial on Cereals, Navrongo.

„ *12.*—"Indore" compost v. "Native", Zuarungu.

„ *13.*—"Indore" compost v. Farmyard manure, Zuarungu.

ROOT CROPS.

Table 14.—Yam Variety Trials, Navrongo.

„ *15.*—Yam Variety Trials, Yekeni.

„ *16.*—Sweet Potato Variety Trials.

MISCELLANEOUS TRIALS.

Table 17.—Groundnut Variety Trials, Zuarungu.

„ *18.*—Rice Variety Trials, Zuarungu.

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APPENDIX IV—TABLE 1.

ROTATION EXPERIMENT, SABIYA.

(Exp.: No. 1/34, 1/35, and 1/36.)

●654 An experiment started in 1934 to test the best means of developing "bush" land.

Layout.—Latin Square.

Replications.—5.

Size of Plots.—1/20th acre.

Mean yields in lbs. per acre for years 1934, 1935 and 1936.

Cropping		1934	1935	1936
A—	Yams	3,124 lbs. tubers	860 lbs.	failed
	millet	(not planted)	—	306 lbs. grain
B*—	Early millet	failed	123 lbs.	240
	guinea corn	87 lbs. grain	122	failed (locusts)
C—	Early millet	failed	100 lbs.	78
	late millet	257 lbs.	178 lbs.	238
D—	Early millet	failed	99 lbs.	36
	groundnuts	164 lbs.	307 lbs.	323
N**—	(Native method)			
	Early millet	—	42	—
	late millet	—	131	—
	alternated with			
	Early millet	failed		16
	guinea corn	54	—	failed (locusts)

*Manured at rate of 2 tons per acre in 1935 and 1936. No manure applied in 1934.

**Native method. This is not exactly what a native would do since no early millet is planted in 'bush' farms.

Note.—Failures are due mainly to the ravages of pests. So far yields do not give a true picture of the condition of this experiment. It is too early to draw any conclusions from this experiment.

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APPENDIX IV—TABLE 2.

8 ACRE UNIT HOLDING EXPERIMENT, NAVRONGO.

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(Exp.: No. 2/35, and 2/36.)

Mean yields per acre from 4 fields each of two acres, worked by one man, his wife and a boy, as a mixed farm unit, with two working bullocks, a ridging plough and cultivator.

Cropping	1935		1936	
	Field	Yield	Field	Yield
Yams (¼ acre)	C	17.6 cwts.	B	31 cwts.
Sweet potatoes (1 acre)		49.7 ,,		20.3 ,,
Coleus potatoes (¼ acre)...		26.5 ,,		10.8 ,,
Cassava (¼ acre)		—		120 ,,
Early millet*	D	36 lbs.	C	86 lbs.
guinea corn		215 ,,		331 ,,
cowpeas		20 ,,		103 ,,
Early millet	A	45 lbs.	D	42 lbs.
late millet		288 ,,		73 ,,
cowpeas		12 ,,		52 ,,
Early millet (¼ acre)	B	107 lbs.	A	failed
groundnuts		115 ,,		442 lbs.
Early millet		failed		failed
Bengal beans		no weights		12¼ cwts. hay

*Manured 2 tons dung per acre. Farmyard manure available for 1937 season.

Conclusion.

A man and his wife with the assistance of a small boy can farm fairly easily 8 acres cropped as above. Experience may suggest desirable modifications.

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APPENDIX IV—TABLE 8.

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CULTIVATION EXPERIMENT IN THE HEADMAN OF GORAGU'S COMPOUND FARM.

(Exp.: Nos. 7/34, 5/35, and 4/36.)

Treatments.—2. To test cultivation before planting on 3' ridges against native practice.

Layout.—Strip method.

Replications.—11.

Size of Plots.—1/20th acre.

Mean yields per acre of grain.

Season	Cropping	Native	Ridged
1934	Early millet	535	980
	guinea corn	66	108
1935	Early millet	660	1,048
	guinea corn	29	472
1936	Early millet	897	1,276
	guinea corn	183	500
Combined grain yield from 1 acre in three years ...		2,370 lbs.	4,384 lbs.

Note.—Cultivations in 1934 and 1935 were done by hand. In 1936 with DY ridging plough. Differences definitely statistically significant in each year.

Conclusion.

There can be no doubt whatever as to the value of ridging under the conditions of this trial. Goragu lies at the foot of the Tong Hills on the North side between Tongo and Shia.

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APPENDIX IV—TABLE 4.

CULTIVATION EXPERIMENT IN THE COMPOUND FARM OF THE HEADMAN OF YEKENI.

(Exp.: Nos. 8/34, 6/35, and 5/36.)

Treatments.—3. To test cultivation before planting on 3' ridges, in rows 3' apart on the flat, against control, native practice.

Mean yields in lbs. of grain per acre.

Year	Cropping	Native	Ridged	Flat
1934	Early millet	17	87	—
	guinea corn	321	270	—
1935	Early millet	219	271	214
	guinea corn	100	145	198
1936	Early millet	305	420	376
	late millet	133	140	144

Note.—Cultivations in 1934 and 1935 done by hand. In 1936 with animal cultivation.

Conclusion.

Definite advantage in favour of cultivation before planting. No difference between ridge and flat. Manuring would probably have an effect. All yields are poor.

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APPENDIX IV—TABLE 5.

CULTIVATION EXPERIMENT ON THE EXPERIMENT AREA AT ZUARUNGU.

Exp.: Nos. 6/34, 7/35, and 6/36.)

Treatments.—3. To test cultivation before planting on 3' ridges, in rows 3' apart on flat against native method.

Layout.—Chessboard.

Size of Plots.—1/40th acre.

Replications.—9.

Mean yields per acre.

Year	Cropping	Control Native	Ridged	Flat
1934	Early millet	63	87	149
	guinea corn	267	241	581
1935	Early millet	150	332	256
	guinea corn	15	36	29
1936	Early millet	156	189	248
	late millet	178	231	292

Conclusion.

Yields are very low and can be accepted only with caution. The balance appears to be in favour of ridging if all factors are taken into consideration—ease of planting and intercultivation, etc.

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APPENDIX IV—TABLE 6.

CULTIVATION EXPERIMENT IN COMPOUND FARM OF ADACHAMA, ZUARUNGU (1936).

(Exp.: No. 7/36.)

Treatments.—2. To test cultivation with Ransomes M.S.N. single furrow plough before planting, against Native practice.

Layout.—Strip method.

Replications.—5.

Size of Plots.—1/20th acre.

Mean yields in grain per acre.

Cropping	Control Native	Ploughed
Early millet	366 lbs.	386 lbs.
late millet	586 „	692 „
cowpeas	49 „	44 „

Conclusion.

Taking the small number of replications into consideration the difference in yield is only barely significant $\left(\frac{Md}{s.e.} = 2.5\right)$. The value of the work was in the ease of cultivation and the cleanliness of the ground in the early stages.

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APPENDIX IV—TABLE 7.

● 654 CULTIVATION EXPERIMENT IN COMPOUND FARM OF ABAGNA, ZUARUNGU (1936).

(Exp.: No. 8/36.)

Treatments.—2. To test cultivation with Ransomes "Victory" plough (single furrow) before planting, against native method.

Layout.—Strip method.

Replications.—5.

Size of Plots.—1/20th acre.

Mean yields in grain per acre.

Cropping	Control Native	Ploughed
Early millet	321 lbs.	401 lbs.
late millet	283 ,,	336 ,,
cowpeas	137 ,,	132 ,,
neri	59 ,,	64 ,,

Conclusion.

These differences did not prove statistically significant but as in Experiment 7/36, ploughing effected a great saving of labour at a critical season.

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APPENDIX IV—TABLE 8.

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ANALYSES OF MANURES USED AT ZUARUNGU IN 1936.

(Analyses carried out by the Agricultural Chemist, Mr. M. Greenwood.)

(Analyses on air dried, fine samples.)

	Native Compost	Zuarungu-made	
		"Indore" Compost	Farmyard Manure
Moisture	3.8	6.2	6.6
Insol. ash	78.8	77.2	67.9
Sol. ash	6.1	6.4	7.4
Loss on ignition	11.3	10.2	18.1
Nitrogen (including nitrates)	.47	.61	.68
P O...	.36	.32	.71
K O	.79	.34	1.13

Note.—The analyses show values on the low side. Those for "Indore" compost and farmyard manure are comparable with published Indian figures.

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APPENDIX IV—TABLE 9.

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MANURIAL TRIAL UPON SWEET POTATOES AT NAVRONGO IN 1934, AND THE RESIDUAL MANURIAL EFFECT UPON MIXED CEREALS IN 1935 AND 1936.

(Exp.: Nos. 9/34, 9/35, 12/36.)

To test 4 tons of manure (leached-out cattle dung from Native Administration kraal) against control, "no manure".

Layout.—Strip method.

Replications.—6.

Size of Plots.—1/20th acre.

Mean yields per acre in lbs.

Year	Crop	Control no manure	Manured 1934 4 tons per acre
1934	Sweet potatoes	2,308 lbs. tubers	3,491 lbs.
1935	Early millet	28 lbs. grain	60 lbs.
	guinea corn	357 „ „	494 „
1936	Early millet	47 lbs. grain	68 lbs.
	late millet	173 „ „	191 „

Conclusion.

Although yields are low, all differences proved statistically significant. There is a definite residual manurial value remaining in the third season after application. Some other factor, other than manuring, requires attention—probably cultivation. The land is badly out of condition.

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APPENDIX IV—TABLE 10.

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MANURIAL TRIAL UPON COLEUS POTATOES AT NAVRONGO IN 1934, AND THE RESIDUAL MANURIAL EFFECT UPON MIXED CEREALS IN 1935 AND 1936.

(Exp.: Nos. 10/34, 10/35, and 13/36.)

To test 4 tons of manure per acre (leached-out cattle dung from Native Administration kraal) against control, no manure.

Layout.—Strip method.

Replications.—6.

Size of Plots.—1/20th acre.

Mean yields in lbs. per acre.

Year	Crop	Control no manure	Manured 1934 4 tons per acre
1934	Coleus potatoes	500 lbs. tubers	784 lbs. tubers
1935	Early millet	21 lbs. grain	115 lbs. grain
	guinea corn	192 „ „	465 „ „
1936	Early millet	44 lbs. grain	64 lbs. grain
	late millet	133 „ „	248 „ „

Conclusion.

Although yields are low all differences proved statistically significant. See remarks, Table 9.

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APPENDIX IV—TABLE 11.

654 MANURIAL TRIALS UPON MIXED CEREALS AT NAVRONGO IN 1934, AND THE RESIDUAL MANURIAL EFFECTS UPON MIXED CEREALS IN 1935 AND 1936.

(Exp.: Nos. 11/34, 11/35, and 14/36.)

To test the effects of 4 tons of manure per acre and 2 tons of manure per acre (leached-out cattle dung from the Native Administration kraal at Navrongo) against control, no manure.

Layout.—Strip method.

Replications.—4.

Size of Plots.—1/20th acre.

Mean yields of grain in lbs. per acre.

Year	Cropping	Control no manure	2 tons manure 1934	4 tons manure 1934
1934	Early millet	14	71	91
	guinea corn	83	211	296
1935	Early millet	10	23	26
	late millet	189	211	336
1936	Early millet	63	93	104
	guinea corn	140	145	227

Conclusion.

The initial level of fertility was too low and the number of replications was insufficient to give us more than an indication of response to manure and residual manurial values. See note, Table 9.

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APPENDIX IV—TABLE 12.

MANURIAL TRIAL AT ZUARUNGU IN 1936 TO TEST "INDORE" COMPOST, AND NATIVE COMPOST AGAINST NO MANURE.

(Exp.: No. 10/36.)

Treatments.—3. 2 tons of "Indore" compost,
2 tons of Native compost,
no manure, control.

Layout.—Strip method.

Size of Plots.—1/40th acre.

Replications.—7.

Mean yield of grain per acre.

Crops planted	No manure	"Indore" compost 2 tons per acre	Native compost 2 tons per acre
Early millet	185	292	373
guinea corn	75	132	108

Conclusion.

All differences proved to be statistically significant. Under the conditions of the trial—typical of some of the poorest land around Zuarungu—the value of such small dressings of manure as 2 tons per acre is definite. It should be noted that whilst weight for weight native compost proved significantly better than Indore compost, a very much greater bulk of manure can be produced by the Indore process from a given head of stock than by the native method. This is important, since it is the gross yield which counts in practice.

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APPENDIX IV—TABLE 13.

MANURIAL EXPERIMENT AT ZUARUNGU IN 1936 TO TEST THE EFFECTS OF "INDORE" COMPOST AND FARMYARD MANURE UPON MIXED CEREALS IN 1936, AND THE RESIDUAL EFFECTS UPON SWEET POTATOES IN 1937.

Treatments.—3. "Indore" compost 2 tons per acre.
Farmyard manure 2 tons per acre.
Control, no manure.

Layout.—Strip method.

Replications.—6.

Size of Plots.—1/20th acre.

Mean yield in lbs. of grain per acre.

Crop	Control No manure	"Indore" compost 2 tons per acre	Farmyard manure 2 tons per acre
Early millet	104 lbs.	207 lbs.	185 lbs.
guinea corn	92 ,,	138 ,,	150 ,,

Conclusion.

The increase in favour of manure over no manure proved to be definitely significant, but not the difference between manures. Again it must be emphasised how much lower these yields are than district means. The site of the experiment was newly acquired. Neighbouring farmers expressed surprise not at the lowness of the yields but that we got a yield at all. It is doubtful whether any residual value remains.

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APPENDIX IV—TABLE 14. 654

YAM VARIETY TRIALS AT NAVRONGO IN 1934, 1935, AND 1936.

(Exp.: Nos. 3/34, 3/35, and 15/36.)

To test nine Dagomba varieties of yam. Yams were planted in mounds made 5′ x 5′, a row with each variety in series. Individual mound weights were taken at harvest and the following table shows the mean weight per bearing mound for the three years of trial.

Variety	Mean weight of tubers per bearing mound		
	1934	1935	1936
Kuki	2.3 lbs.	1.55 lbs.	4.20 lbs.
Dapam	2.8 ,,	1.53 ,,	2.05 ,,
Labaco	2.3 ,,	1.04 ,,	2.75 ,,
Puno	1.9 ,,	1.70 ,,	2.97 ,,
Fugra	1.9 ,,	1.68 ,,	2.50 ,,
Zilambo	1.8 ,,	1.68 ,,	2.36 ,,
Peringa	1.6 ,,	1.14 ,,	1.81 ,,
Lili	1.4 ,,	1.07 ,,	2.24 ,,
Chenchito	1.2 ,,	—	—
Mean for all varieties ...	1.9 ,,	1.64 ,,	2.67 ,,
Bearing mounds	335	1,022	652
Percentage bearing ...	83%	67%	78%

Conclusion.

Kuki appears to be the best variety we have found up to date.

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APPENDIX IV—TABLE 15.

YAM VARIETY TRIALS AT YEKENI IN 1934, 1935, AND 1936.

(Exp.: Nos. 4/34, 4/35, and 16/36.)

To test nine Dagomba varieties of yam. Yam were planted in mounds 5′ x 5′, a row with each variety. Individual mound weights were taken at harvest. The following table shows the mean yields per bearing mound obtained for each year of trial.

Variety	Mean weight of fresh tubers per bearing mound		
	1934	1935	1936
Kuki	4.3 lbs.	3.30 lbs.	2.57 lbs.
Dapam	2.6 ,,	—	2.30 ,,
Labaco	2.4 ,,	—	—
Puno	3.1 ,,	3.90 ,,	2.13 ,,
Fugra	3.2 ,,	1.15 ,,	—
Zilambo	2.9 ,,	2.80 ,,	2.11 ,,
Peringa	2.8 ,,	—	—
Lili	3.0 ,,	2.60 ,,	2.09 ,,
Chinchito	1.9 ,,	—	—
Mean weight for all varieties	2.9 ,,	3.02 ,,	2.23 ,,
No. bearing mounds ...	301	141	116
Percentage bearing ...	71%	50%	46%*

*32% of seed yams were stolen two weeks after planting.

Conclusion.

The varieties Kuki, Puno, and Dapam appear to be the best. Yields are too low to warrant extensive extension.

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APPENDIX IV—TABLE 16.

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VARIETY YIELD TRIALS OF SWEET POTATOES AT ZUARUNGU AND NAVRONGO IN 1935 AND 1936.

(Exp.: Nos. 17/35, 19/35, 19/36, 20/36.)

To test three local varieties of sweet potatoes:—

Nanuri-sunga, entire leaves, red stem, red tuber.

Nanuri-punga, entire leaves, white tuber.

Nanuri-yadaga, indented leaves, white tuber.

Layout.—Strip method.

Replications.—6.

Size of Plots.—1/40th acre at Zuarungu.

1/20th acre at Navrongo.

Summary of mean yields in cwts. per acre.

Variety	Zuarungu		Navrongo	
	1935	1936	1935	1936
Nanuri-sunga	30 cwts.	14 cwts.	62½ cwts.	7½ cwts.
Nanuri-punga	40 „	32½ „	42½ „	24 „
Nanuri-yadaga	43 „	34½ „	40½ „	34 „

Conclusion.

Difficulty has been experienced in each year in obtaining sufficient planting material. Nanuri-sunga is the least vigorous of the three varieties and suffered most, except in 1935 at Navrongo. The reason for the comparatively high yield in that year is not understood.

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APPENDIX IV—TABLE 17.

GROUNDNUT VARIETY TRIALS AT ZUARUNGU IN 1934, 1935, AND 1936.

(Exp.: Nos. 13/34, 20/35, and 21/36.)

To test the relative merits of an upright (bunch) type of groundnut from Nigeria against the local procumbent variety. It was considered that a bunch variety would prove more suitable for work with animal drawn implements.

Layout.—Strip method.

Replications.—11 (only 6 in 1934).

Size of Plots.—1/40th acre.

Mean yields in lbs. per acre (dry in shell.)

Year	Method of Planting	Local Procumbent	Nigerian Bunch
1934	Flat 9″×9″	784	1,043
	Flat 18″×18″	936	744
1935	Flat 2′×1′	810	998
	Ridge 2′×1′	788	835
1936	Flat 1′×9″	1,075	1,174

Conclusion.

Although the differences are not statistically significant, the balance goes in favour of the bunch variety if for no other reason than the ease of harvesting. In 1936 the labour required to harvest the Nigerian groundnut was 30% less than for the local.

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APPENDIX IV—TABLE 18. 654

RICE VARIETY TRIALS AT ZUARUNGU.

To test the following varieties:—

Tamale Black Selection.
Tamale Yellow ,,
Essiama NZ2 ,,
Essiama NZ4 ,,

1934. Single observation plots of ¼ acre were put down in 1934.

1935. Statistical layout was adopted.

Layout.—Strip method.

Replications.—5.

Size of Plots.—1/20th acre.

1936. Tamale Yellow, which had proved most satisfactory was tested against Local.

Layout.—Strip method.

Replications.—10.

Size of Plots.—1/40th acre.

Mean yields of paddy per acre are given below.

Variety	1934	1935	1936	Straw 1936
Tamale Black	1,463	1,605	—	—
Tamale Yellow	1,747	1,589	1,411	5,900 lbs.
Essiama NZ2	1,822	1,087	—	—
Essiama NZ4	1,742	912	—	—
Local	—	—	1,089	5,856 ,,

Conclusion.

The high return of grain and straw from rice locally and the comparative ease of cultivation with bullock drawn implements, makes rice a particularly desirable crop for the mixed farmer to grow.